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Office of the Secretary
Federal Communications Commission
Washington D.C. 20554

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Re: Notice of Proposed Rulemaking;
Amendment of Parts 2 and 15 of the Commission's Rules to Permit
Use of Radio Frequencies Above 40 GHz for New Radio Applications;
ET Docket No. 94-124, RM-8308; Released November 8, 1994

The attached reply comments concerning the use of radio frequencies above 40 GHz for new radio applications are submitted on the behalf of Toyota Motor Corporation, in response to FCC's Notice of Proposed Rulemaking as outlined in Docket No. 94-124, released on November 8, 1994.

Should NHTSA have any questions about these comments, please contact Mr. Chris Tinto of my staff at (202) 775-1707.

TOYOTA MOTOR CORPORATE SERVICES OF
NORTH AMERICA, INC.

Saburo Inui

Saburo Inui
Vice President

SI:ct
Enclosure

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COMMENT ON FCC'S NOTICE OF PROPOSED RULE MAKING
BY TOYOTA MOTOR CORPORATION

SUMMARY

This is a comment to the FCC's Notice of Proposed Rule Making which was released on November 8, 1994.

We agree with the already proposed Vehicular Radar Bands, however we request to add 60-61GHz to unlicensed vehicular radar bands. As for the output power, we agree with FCC's proposal on power density of unlicensed vehicular radar bands.

INTRODUCTION

・Development of Millimeter-wave Radar in Japan

Systems to detect obstacles ahead of automobiles by radar sensors and to warn drivers of hazardous conditions have been studied since the 1960's. In 1991, a collision warning system using a laser radar was commercialized for heavy duty trucks.

While laser radar sensors have the advantages of compact size and relatively low cost, they also have serious drawbacks, such as significant performance deterioration caused by influences of weather conditions such as rain, fog, and snow. In such regards, radar sensors using radio waves have less serious

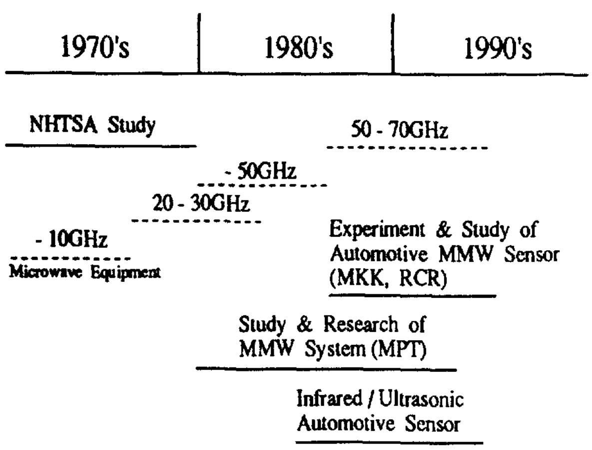

Fig. 1. Development of Millimeter-wave Radar Sensor

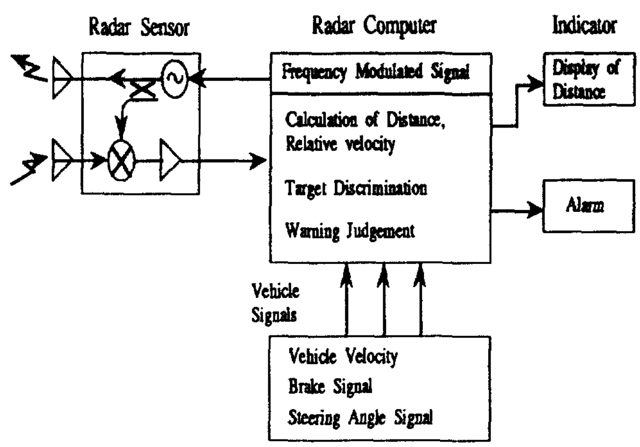

Fig. 2. Composition of Radar Warning System

problems, and therefore are considered to be more useable as automotive sensors.

With regard to radio wave radars, supply of millimeter-wave RF devices and rule restrictions have been the main problems. However in the 1980's, the MPT promoted the development of millimeter-wave RF devices as millimeter-wave component technology and investigated millimeter-wave technology as preparations for rule making (Fig.1).

In the 1990's, accompanied with progress of communication media, development of RF devices has been accelerated, and an experimental millimeter-wave frequency band was set for the purpose of progressive development of radio wave resources.

Accordingly, RF devices of millimeter-wave band, particularly, 60GHz band, and application systems are being developed actively now.

· Composition of Automotive Radar System

An example of a radar applied collision warning system is shown in Fig.2. From the receiving information of the radar sensor mounted on the front, the distance and the relative velocity between the vehicle ahead and the radar vehicle are calculated, and consequently, based on these information and additional vehicular information, the critical value is estimated. If this value exceeds that of an ordinary situation, the alarm is activated and the driver is warned to act correspondently.

As advanced systems, a distance control system and an auto-braking system are also proposed.

BACKGROUND

· Reason of Selecting 60GHz Band

In Japan, the Millimeter-Wave Sensing System Study and Research Committee which was active in the 1980's evaluated 50, 60, and 70GHz radar sensor as automotive radar system.

This committee clearly pointed out that electro-magnetic interference would become a serious problem in case of automotive radar mass production.

In discussing this problem, the use of the 60GHz band, in which propagation attenuation by oxygen is large, was considered desirable for the following reasons.

1) Since the propagation distance of a radio wave is short, it is possible to separate spatially even if the same frequency is used repeatedly. Therefore frequency resources can be used efficiently.

2) Since automobiles move around, interference with other radio facilities might occur. But by using this band, radio waves can not reach any far field, and therefore interference possibilities are minimized.

· Trend of Development of Millimeter-wave RF Devices

In Japan the development of millimeter-wave has been concentrated to one frequency band for the purpose of developing millimeter-wave devices efficiently.

To be more concrete, the MPT allocated 59-60GHz to the experimental millimeter-wave band in November 1992 in order to acquire experimental license easily, and set the 59-64GHz band as the goal of development.

Consequently the development of device makers has been concentrated to the 60GHz band.

REQUEST

Our request is to add 60-61GHz to the Unlicensed Vehicular Radar Bands.

As for the output power, we agree with FCC's proposal on Unlicensed Vehicular Radar Bands in which the maximum power density is defined as 30μ W/sq. cm.

Our requested band width of 1GHz is determined by considering modulation band width and frequency stability.

EVALUATION OF 60GHz RADAR

We have evaluated 60GHz radar as an automotive sensor.

As results, characteristics of propagation, scattering patterns, and radio interference are described in the following.

(1) CHARACTERISTICS OF PROPAGATION

We investigated how rain, fog or snow would affect automotive radars in the on-vehicle conditions.

The attenuation of several tens of meters propagation in heavy rain at the rate of 20mm/h was very low, however the attenuation by water drops on the surface of the sensor was observed as 2 to 3 dB.

As for fog and snow, propagation attenuation was not observed, but snow accumulation on the surface of the sensor caused attenuation at the rate of 10dB for 40mm thickness. This phenomenon could be decreased by sensor surface coating improvement.

(2) SCATTERING PATTERNS

Detected objects such as vehicles and guard rails consist of many different shapes and forms. Measuring different scattering patterns according to shape is very important for distinguishing between target objects.

Fig. 3 shows the cross sectional scattering patterns measured for four types of vehicles. Cross sectional scattering patterns of passenger vehicles are large in the front and rear directions but diagonally very small. Scattering patterns of

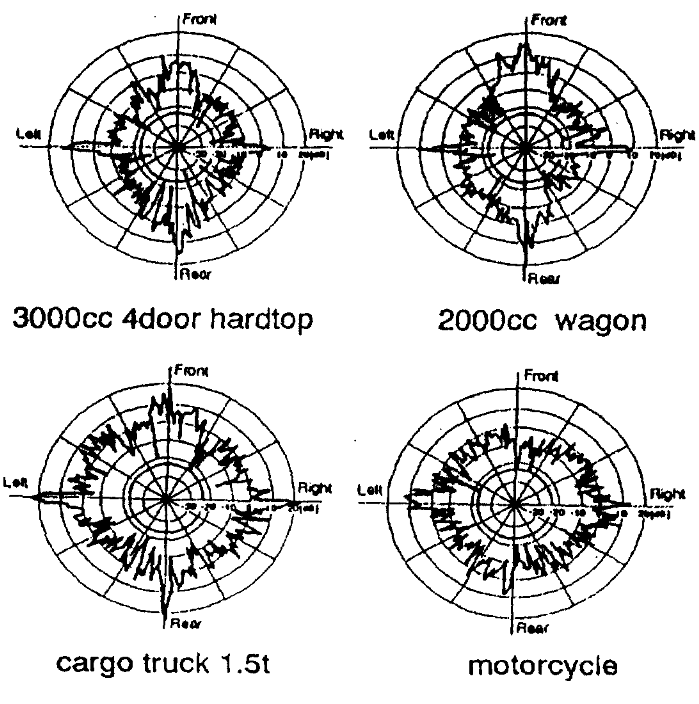

Fig. 3. Scattering Pattern of Vehicles

trucks and motorcycles are almost the same in every direction, but those of motorcycles are smaller.

Measuring scattering patterns for roadside objects were also carried out. Since the directional reflection pattern of flat target objects, such as guard rails and traffic control signs, is narrow and sharp, reflection signal power, while driving, is expected to be small unless such objects appear just in front of the radar vehicle.

However, as cylindrical objects like metal pipes are nondirectional and have a relatively high reflectivity, reflections from poles such as roadside street lights may be obstacles to radar detection.

(3) RADIO INTERFERENCE

In the future, when radar systems are installed in a large number of vehicles, mutual interference between similar types of radar systems is expected to occur. In order to assess radio interference, radar sensor systems were installed in two vehicles, moving in opposite directions, and the level of interference was measured in one of the vehicles, as a function of changes in distance (R) and angle (θ) (See Fig.4). The case where two radar vehicles run parallel was

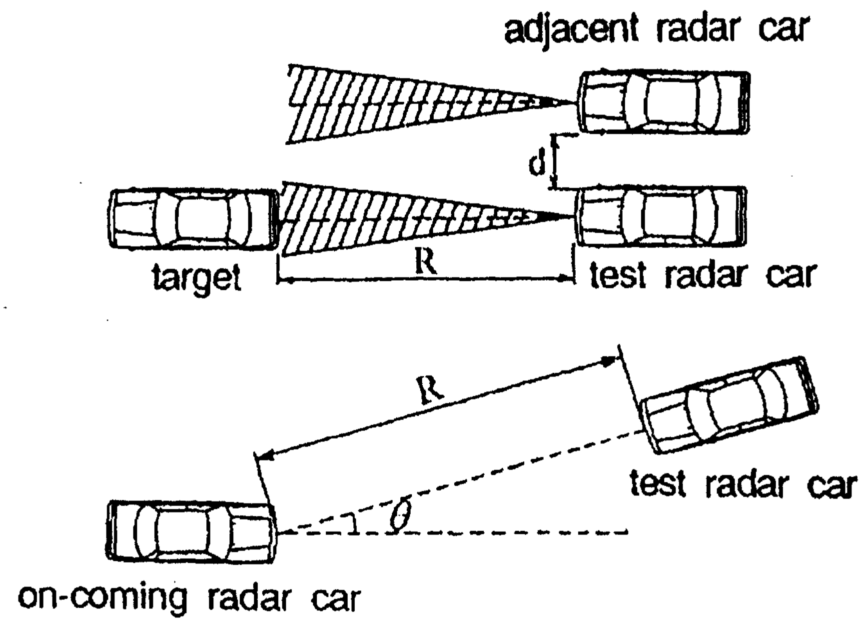

Fig. 4. Test of Mutual Electro-magnetic Interference

also investigated.

As confirmed, the interference did not occur in both cases. The experiment demonstrated that when two vehicles approached each other from opposite directions the interference level was well suppressed by the effect of a polarization of 45 degrees. When the two vehicles ran parallel to each other, the necessary separation ratio was attained by sharpening the directivity of the beam.

CONCLUSION

According to our testing, a radar sensor of 60GHz frequency was proven to perform well for an automotive radar system, and is considered not to be problematic for practical use.

In addition, considering interference problems in the case of automotive rader mass production, selecting 60GHz, in which attenuation by oxygen is large, is favorable because the propagation distance of radio waves can't be long.